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# Examination of Disaster Telemedicine and Community Resilience

## Abstract

I investigated the state-of-the-art in rapid wireless network deployment in disaster areas, more specifically their applications and solutions for telemedicine and community communications.  In situations, such as the recent earthquakes in Haiti and Chile, there has been a need for those in the disaster area to reach out to both medical assistance but also contact their family, potentially in other parts of the world.  Given the lack of infrastructure in many disasters, wireless networks are the only effective option.  With the prevalence of Web 2.0 user-driven content, are the communities capable of reaching out to loved ones over the internet in a disaster?

With the recent tragedies, tsunamis, terrorist attacks and the like, research is very active in the subject of rapid wireless network deployment for logistics and aiding medical workers, without a focus on the victims.

# Introduction

Three important and very different technologies are improving the methods by which rescue and aid workers deploy into a disaster area and bring hope to the victims. Ad-hoc wireless networks can provide communications for rescue crews as well as medical workers. While good communications are important to the workers, another technology may play a part in both the workers and the victims’ lives. Web 2.0 tools allow the world to aid in the mission of a rescue worker, as well as provide a platform for community resilience. Building Web Apps or Web Services for broadcasting messages and indexing messages can be rapidly developed using black box or open source technology to handle a specific disaster with ease. Lastly, handheld devices provide near-instant information to rescue workers of all kinds. The integration of these three technologies greatly impacts the effectiveness of rescue workers and increases community resilience.

There are many situations where it is important to have ad hoc wireless networks in place, for command & control (C2) and medical purposes.  One of these situations is a disaster, such as a tsunami, earthquake or terrorist attack. The goal of the ad hoc network varies by your role in the disaster.  For the rescue workers the network’s primary goal is to provide C2 for operations.  The perspective of the medical staff is somewhat similar, but it is more focused on patient triage.  Typically makeshift hospital centers are set up at various locations in the perimeter with different capabilities. Therefore logistics associated with moving patients to where they need to go becomes a very important problem that is addressed with ad hoc wireless communications.

There is another group of individuals in a crisis, which are typically not considered users.  The victims in the immediate area as well as the surrounding areas have a need for communication. Technology at the disaster site can aid them in linking together separated families; sending messages pertaining to health and welfare; finding shelter information; locating safe passage; as well as other outreach to the world and their families. People who may be related to the victims may be located well beyond the scope of the incident and would like to know how their family is.

Generally victims are focused on surviving and receiving immediate help, but they also tend to want to find their family members who may have been separated during the event or in the ensuing chaos.  The chaos faced by rescue workers and victims includes unsafe situations with desperate people trying to survive as well as a criminal element [5]. A lot of makeshift shelters are currently used for reuniting families with children. These makeshift shelters are often part of medical facilities, with waiting areas, emergency rooms, theatres, and recovery areas focused on chaos reduction [5].

# Command Communications

In the event of a disaster, such as an earthquake, mudslide, tsunami, explosion, there are many problems faced by aid workers.  Aid workers are not simply the people bringing medical supplies, but also the fire brigade, police, and other workers on scene making a best effort to save lives.  One of the larger issues in this situation is logistical command and control.  The people with full situational awareness and maps[[1]](#footnote-1), and force counts need to be able to direct the efforts.  If each effort of rescuing is done entirely without guidance than this can lead to problems with insufficient medical supplies prepared as well as other logistical problems.   Phone lines can to be out when there is a disaster or the lines in place can be clogged by calls from those who can find a phone.  This depends heavily on the level of development of the area. Both situations impede worker communications (cellular towers more likely the issue), driving a need for separate wireless communication network.

To lead a large group of people in an area where normal communication methods may fail or be inadequate, special communications equipment may be required.  Headquarters will need the capability to communicate effectively with at least one person per effort.  Within an activity or effort it may be sufficient that they can all intercommunication separately from the headquarters system.  Although sufficient, it is more effective if all the systems interoperate.  This allows rescue workers in the rubble to send back information including global positioning system (GPS) coordinates, altitude, images, text and video to medical workers and other rescue workers to bring more rubble-moving equipment and prepare appropriate medical equipment.

To better handle logistics in disaster situations, an area is typically broken into different sections.  This method is called “separation of the room.” [1] Each partition of the area supports a different mission function, such as triage or transportation.  This division of physical space also provides for an interesting communications arrangement.  Each section may need to pass information forward for ad-hoc logistics, or pass information to a central command and control center to manage the entire scene.

There are advantages to having a centralized communications point; but this also has limitations for fast-action scenarios.  In the model built by [1] there are many restrictions on when and which nodes can join the network.  These restrictions do not necessarily support telemedicine, as they focus more on disaster management in a more general sense.  The goal of their work is to support the rapid movement of peoples from a disaster area, with varying medical waypoints.  It appears that very little medical information is transmitted forward, as each medical situation is handled at the appropriate area.

Experiments have been performed by deploying disaster communications in the physical world, instead of computer simulations.  One such experiment demonstrated the DUMBO I/II emergency networks.  The experiment took place in a forest with elephants carrying equipment.  The important telemedicine aspect of their system is that whenever an injured individual is found the information and the condition of the victim is sent back to headquarters for evaluation [2].  A possible improvement to the system would have a medical sub-headquarters and the information was sent there; giving the medical staff notice for what is down the road.  This will address the unique needs of the medical staff.

Both systems use Mobile Multi-hop Adhoc Networks (MANETs) to handle all tactical and medical information. A MANET is a node on a network that both transmits its own data and routes data from nearby nodes. With each device acting as both network user and network router, the nodes fall into a mesh. Challenges associated with MANETs are beyond the scope of this paper [6].

# Telemedicine

When a rescue worker finds an injured individual or group of people; information needs to be relayed back to someone with medical expertise.  This allows them to decide and direct the rescue worker on who is in the most immediate need of medical attention, what to do if it is slightly more complicated than setting a broken bone, or possibly to immobilize the injured person until help arrives.  In addition to this nurses may receive instruction from doctors who are down the road out of the disaster itself.

Once a patient is to a more secured medical facility, doctors on scene may communicate with video conferencing to doctors elsewhere with the more specific expertise to aid.  The capability to upload scans of medical imaging and records from the disaster site can also allow doctors off-site to give their opinions even if they’re in different time zones.

## Handheld Devices

There has been work in building software for handheld devices to support medical applications in search and rescue operations. Search and Rescue teams carry with them certain equipment, including a global positioning system (GPS). With the improvement of personal digital assistants (PDAs) it would be reasonable for some workers to carry those around instead of a GPS-only handheld device. A prototype system was built that transmitted patient information back a headquarters unit. The system attempted to disseminate text, video, vital signs, and medical images as well as other still images. The handheld device would need to be plugged into a medical imaging device to make use of it. However, sending video and still images back regarding a victim found in rubble is infinitely more useful than just their location [3].

# Web 2.0

Web 2.0 is typically defined as the shift from publisher generated content to user generated content as well as proliferation of broadband access.  User generated content includes reference information, videos for others to consume as well as blogs (online journals), and photos either shared through some social networking site or through a free use gallery site.  As these systems became more and more used the internet content trended towards most content coming from other users. These services are paid for by website advertising. Another portion of Web 2.0 technology which isn’t necessarily commonly addressed is the separation of website data and the website GUI. This change allows many different views of a website, with the same data. Therefore, a handheld device with a small screen can access the website with a different view and receive the same information.

## Open Reference

There are many user driven efforts to build reference information on the internet, such as Wikipedia.org and OpenStreetMap.org.  This information is meant for consumption by all internet-connected users on the Earth.  However, some tools are quite useful for disaster workers as well as disaster victims.  OpenStreetMap.Org is a project aimed at building a map system that is entirely controlled by the Internet users.  People can add items of interest, new roads, and such with the intent of increasing global information.  Before the recent disaster in Haiti, the OpenStreetMap for that area had little to no information, but immediately after the event the map was built up and made complete by users around the world attempting to support the aid workers.  This map had all the refugee camps listed, as well as functional hospitals and passable roads.  This information directly aided workers [7].



OpenStreetMaps.org Loaded on a Garmin Handheld GPS in Haiti [7]

## Mashups

The combining of different information on the internet for mass consumption is called a Mashup.  A popular type of mashup involves combining data regarding a region, such as crime and a map.  Effectively you’re doing what weather broadcasters do when they overlay the weather information on a map or the associated region.  This effort can be somewhat time-consuming, but isn’t necessarily.  The internet orientation of such a task allows many mashups to be crowdsourced.  Crowdsourcing is the distribution of labor among a large quantity of mostly anonymous users.  Mashups have been a proven success of the Web 2.0 Internet and a contributing factor for telemedicine on a local and global level.  In [4] the researchers gathered up data by scraping the Centers for Disease Control (CDC), United States Geological Survey (USGS), and the National Climate Data Center websites.  Although these websites were not set up to support such scraping, the limited data was gathered and overlayed on a map of the region, from Google Earth.  Google Earth is a web mapping service supported by Navteq.  In addition to providing maps, they also provide directions.  From a public medicine perspective this mashup detailed by [4], the information was useful.  It provided information on the correlation between temperature change and the West Nile Virus incident rate.  This is only one example of using different pieces of the internet to provide health information.

## Online Video

Publishing videos and still photographs for the global consumption is a large part of Web 2.0.  Whether it’s via social networking sites like Facebook or strictly image based sites such as Flickr.  Google owns the website Youtube.com, which is popular for posting videos to private or public audiences.  Within this site one can build a channel.  Channels can be used for focused videos, such as all videos from UMBC, or all videos on a subject or by an author. The Red Cross or a similar organization could open a YouTube channel for the victims.

## Handheld Devices

A new population of internet users is growing; mobile users. Mobile users are people viewing and interacting with the internet via handheld devices. These handheld devices tend to have small screens and little bandwidth. Because of these restrictions there has been a movement towards separating the data from the view on websites. This shift allows websites to have smaller webpages specifically for handheld devices. In a disaster site, a handheld device with access to information such as OpenStreetMap.org, or even weather information is very useful [7].

# Broadcasting Well-being

Typically there are quite a few relatives and friends of disaster victims living very far from the site itself.  These friends and relatives possibly live in other countries entirely.  In a disaster event, phones tend to be clogged with calls or down entirely and there is therefore no way to determine the well-being of those in the disaster area.  Those here in the States for instance watch the news hoping to see a clip of their friend at a refugee camp.

People within the disaster site itself may try to find each other at varying refugee camps as well as get messages out to their families.  Currently the burden to report information back is on the Red Cross workers, who may be overworked making a best effort attempt to save lives and help those in need with shelter, blankets, and food.

In the current world whenever there is a disaster, websites spring up overnight, some legitimate aid efforts, other fraudulent, pertaining to disaster relief.  The purpose of these websites is to build up financial aid, because money can help quite a lot in disaster recovery.  Without donations and aid from the world at large, then those in need would stay in need and the area would become a third world.

## Messages of Hope

It would be rather trivial to set up a channel on a Youtube.com-esque site or a site devoted to aid that published videos from “ground zero.” or messages of hope and well-being from those affected by the disaster.  This website could easily be run with some of the money provided to the victims.  It may seem less important than food, but the effect it can have in getting the information out about the victims themselves may help.

Broadcasting information that is important to those victims about their families and their condition may bring more global awareness to the plight of their situation, but more importantly allows their family members out of the area to learn of their condition.  This information may bring peace of mind to people affected by the disaster.  The link of information exchange could likely run both ways, but this can get rather expensive.  And with many people in need, if two way communications are provided then a contention can form for a community resource.

The disaster workers on site would likely not support the broadcasting, but this could easily be supported via wireless broadband or satellite link from the refugee camps.  The Red Cross workers could have a tent with a video camera, hooked up to some basic laptop equipment.  Possibly a ruggedly equipped laptop would serve the purpose sufficiently.  The messages could be tagged by family name, so that those in other locations could easily get the information most relevant to them.

# Recent Events

In January, 2010 there was a rather large earthquake in Haiti.  Nurse Deb Lau recently published her experiences working in a makeshift field hospital at the site only six days after the earthquake.  She described the types of injuries, with which the workers had to deal as well as the security and the field hospital arrangements themselves.

For the most part the injuries faced by the workers required no specialized medical or surgical equipment.  The scene described was a calm chaos.  Largely, the Haitians continued with their lives as though relatively unchanged by the disaster.  However, at night this was sometimes a different story because many survivors were desperate for food.  Also, there are often criminals attempting to seize control of an area in a catastrophe, with the goal of exploiting others.  Telemedicine was not identified as playing a part in their work.  It's very likely they used GPSs with recently updated maps to find the location of the field hospital. It was placed on a double set of tennis courts.  But beyond this, technology was not mentioned once.  At night, the workers had to leave the field hospital for safety reasons and head back to their base camp.  While they were gone, the hospital was managed by the Haitian workers.  Because the expertise of the foreign aid workers might have been necessary if any complicated medical situation arose in the night, the workers had to call-in regularly as well as potentially drive over.  Nurse Lau reported that they never had to drive to the remote field hospital, but there was a concern that this would be unsafe.  If the field site had video conferencing capabilities, the workers could have possibly directed the field site workers remotely [5].

Although no obvious telemedicine was referenced in the article, it is known that other teams involved in the rescue effort utilized wireless communications. The extent telemedicine played in this disaster is undocumented at present.

# Future Work

Given that disasters will continue to occur throughout the world, there is a fair amount of active research in emergency preparedness. Currently most research is in supporting rescue efforts, versus telemedicine or community resilience. Therefore, there are several open research questions. Also, because there is not a lot of literature on these ideas, there is still an open research need.

## Useful Video versus Costs

Provided the infrastructure can be built to support short videos from a disaster recovery area. The following questions need to be answered. Is this worthwhile? Will the victims feel there is benefit; will the relatives off-site utilize the system? There are also concerns over data retention. How long after the disaster should the videos be kept? Storing data costs money, who will pay for this? If a major corporation such as Google donates storage space; what responsibility do they have for providing access. If the world is skimming through videos, this creates a lot of bandwidth and this costs money.

## Cheap Transmission

Provided that there is a place to store the videos for distribution. There are issues associated with transmitting the data from the site. If the videos are taken from a recovery site and stored on a hard disk drive there, they still need to be transmitted home. Allowing that there is a method of transmitting data off-site, this is a community resource. Will contention arise between the rescue workers attempting to transmit important medical data off-site or these videos? Transmitting data is rather expensive and users pay by the byte. Who is going to pay for this transmission?

## Disaster Telemedicine

If there is a disaster in a remote region, can local doctors who are less specialized teleconference with more specialized doctor’s off-site for a productive result? There is research in tele-robotics, but is this equipment unrealistic for rapid deployment?

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1. Maps loaded on handheld devices can aid workers outside of headquarters and allow for some decentralized decision-making. [↑](#footnote-ref-1)